SUB-DOPPLER FREQUENCY METROLOGY IN HD FOR TESTS OF FUNDAMENTAL PHYSICS

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Molecular hydrogen has evolved into a benchmark quantum test system as highly accurate measurements can challenge the most accurate theoretical calculations, which allows for various tests of fundamental physics. Especially the rovibrational splitting serves as an excellent probe to put constraints on the strengths of putative fifth forces in nature.

Recent Doppler-free measurements in the (2,0) overtone band of the hydrogen deuteride molecule provided an ongoing stimulating debate on how to interpret the unusual line-shapes. The obtained saturated spectra differ significantly from an ordinary Lamb-dip, or even manifest itself as a 'Lamb-peak' for the P(1) line.

Here we present an overview of our latest work on the hydrogen deuteride molecule to provide insight in this conundrum. Doppler-free measurements were obtained with our frequency comb referenced NICE-OHMS spectrometer and carefully compared with numerical optical Bloch simulations to extract an accurate prediction of the hyperfineless transition frequency. This shows that levels of accuracy and resolution are reached where the hyperfine contribution cannot be neglected for accurate determination of rovibrational transitions in the hydrogen deuteride molecule and is the origin of the distinctively shaped Lamb-dips and peaks [a,b,c].

[a] F.M.J. Cozijn *et al.*, Sub-Doppler frequency metrology in HD for tests of fundamental physics, *Phys. Rev. Lett.* **120**, 153002 (2018)

[b] M.L. Diouf *et al.*, Lamb-dips and Lamb-peaks in the saturation spectrum of HD, *Opt. Lett.* **44**, 4733 (2019)

[c] M.L. Diouf *et al.*, Lamb-peak spectrum of the HD (2-0) P(1) line, *Phys. Rev. Res.* **2**, 023209 (2020)